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VR Malaysia FestiWorlds: Development of 3D Virtual Reality Application

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Abstract

Malaysia is renowned for its multicultural diversity, with each ethnic group having distinct cultural traditions and celebrating various festivals. Unfortunately, the cultural gap is widened due to a decline in the transfer of traditional knowledge and festival experiences to younger generations. Thus, this research is aim to design VR Malaysia FestiWorlds using a 3D approach, develop the application utilizing virtual reality technology, and conduct alpha and beta testing with target users. The target users for this project are public aged 7 and above. TRES-D methodology employed to develop the application by utilizing primary school sixth-grade history textbooks and subject matter experts as a guide. The implementation of VR technology allows users to virtually explore Malaysia's multicultural festivals without being physically present, presenting an opportunity for future cultural preservation efforts and educational enhancements. The method used in user acceptance testing was based on the System Usability Scale (SUS). The Acceptability Ranges score scale places the average score of 86.25 into the "acceptable" range and "Excellent" is the adjective rating. Overall, the built-in application effectively satisfies the needs of the target users.

1. Introduction

In this era of technological advancement, virtual reality is a metaverse core technology that combines human-computer interaction, computer graphics, sensor technology, and artificial intelligence. It resembles reality or imagined world by using specific hardware and software, allowing users to interact with the virtual world. Besides, VR technology has become more affordable in recent years, and more researchers have begun to investigate how it may be used to boost learning [1].

Malaysia is a country known for its multicultural diversity, with each ethnic group having its own unique cultural traditions and celebrating various special festivals. The diversity in festivals are an outstanding representation of Malaysia cultural richness and unique celebrations with the Malay, Chinese, and Indian communities. This diversity is reflected in Malaysia's languages, customs, religions, festivals, and cuisines. These festivals provide a unique opportunity to learn about the multicultural customs, food, and traditions of Malaysian multi- ethnic groups.

Currently, there are lack of local content in existing applications to promote the Malaysia culture. This had led to a lack of knowledge and understanding of Malaysian ethnic festivals among the young generation. Despite their easy access to new technologies and electronic devices, the younger generation shows relatively low interest in the study of culture and heritage because they find it boring and outdated [2]. Within this context, the issue

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becomes apparent when the young generations of each ethnic group are believed to be less capable of preparing their traditional festival cuisine. Even if they have such knowledge, it is merely based on common knowledge of culture and heritage [2]. Moreover, the young generations of each ethnicity are limited to the preparation of the festival cuisine, like *lemang* during Hari Raya Haji, although they have knowledge of it [3]. Besides, there is a lack of immersion tools like virtual reality (VR) when attempting to educate individuals about Malaysian multicultural festivals. While platforms such as Steam provide VR experiences concentrating on music festivals, such as "Hop Step Sing: Happy People," [4] there are presently no applications that especially focus on Malaysian festivals, highlighting the need for such unique and culturally immersive tools.

The objectives of this study are to design VR Malaysia FestiWorlds based on 3D approach, to develop VR Malaysia FestiWorlds application by using virtual reality approach, and to implement alpha and beta testing on the developed application to the target user. The application was developed for public users suitable for users aged 7 years old and above. The subject matter expert (SME) participating in this project is Teacher Gent Tan Qi Yi, who has 7 years of teaching experience in Primary 6 History subject at Qi Meng Education Centre in Johor.

The VR Malaysia FestiWorld application offers an immersive theme park experience, combining education and enjoyment to showcase cultural events in English. It covers festivals celebrated by major ethnic groups in Malaysia, including Malay, Chinese, and Indian. The app features two main modules: learning about each ethnic group's festival and traditional foods, and amusement rides with traditional decorations. The application offers an immersive VR experience for users to explore Malaysian festivals, including decorations, food preparation, and cultural significance. Users can navigate a theme park and select amusement rides, each visually distinct. Interactive buttons allow users to interact with virtual objects and festival elements and adjust audio settings to match the atmosphere.

The rest of the paper is arranged as follows: Section 2 covers the domain of study, the technology used, and the result of the comparative analysis. Section 3 describes the TRES-D (ThREe dimensional uSer interface Development) methodology and the output of each phase of this project.

2. Related Work

This section discusses the study domain, technology used, and result of the comparative analysis.

2.1 Malaysia Festival

Malaysia is a country famous for its multiethnicity and multiculturalism, each race has its own unique cultural traditions, and they celebrate a variety of special festivals at different times. Malaysia's multicultural festivals are an important expression of the country's cultural wealth, and the Malay, Chinese and Indian are the main races in the country. Each race has its own unique customs and practices, creating a variety of celebrations that characterize the Malaysian cultural landscape. They will prepare a variety of traditional foods during the celebration, the most representative food for Malay celebrates Hari Raya is *lemang*, for Chinese celebrates Chinese New Year is *niangao* and for Indian is *murukku* [3].

The preservation of Malaysia's cultural heritage is significantly influenced by the sharing of knowledge and techniques for festival preparation among different races and it is commonly transmitted through older generations to younger generations. In [5] stated that every generation in Malaysian society practices the hierarchy of families, with older people generally having greater wisdom and experience. The social structure is significant since it has connections to traditional practices followed by all races. Besides, Sejarah textbooks in Standard Six Chinese Vernacular Schools (SJKC) are utilized to disseminate knowledge about Malaysia's cultural festivals, particularly Unit 6, as a physical medium [6].

2.2 Virtual Reality Technology

Virtual reality is a complex user-computer interface that enables real-time simulation and interaction via a variety of sensory channels such as visual, aural, tactile, sense of smell, and taste [7]. It also can be known as a simulation that uses computer graphics to create a realistic environment that reacts to human input and ensures real-time interactivity [7]. In recent years, virtual reality technology is increasingly crucial in various fields like medical, marketing, education, and commercial applications, offering a dynamic and innovative tool that transcends traditional boundaries.

There are many types of Virtual Reality, the types that will be discussed are non-immersive virtual reality, semi-immersive virtual reality, and fully immersive virtual reality. Non-immersive virtual reality can be known as semi-immersive systems, maintain visual awareness of the real world while allowing users to see the virtual world through a display device [8]. Semi-immersive virtual reality, such as advanced flight, ship, and vehicle simulators [8]. The semi-immersive virtual reality provides users to engage with a partial virtual environment (VE). This sort of virtual reality is mostly utilized for teaching and training, and the experience is made feasible by graphical computing and huge projection systems [9]. The fully immersive virtual reality (VR) is a digital technology which enables users to interact with artificial settings as if they were in the real world. In other words, users sense a

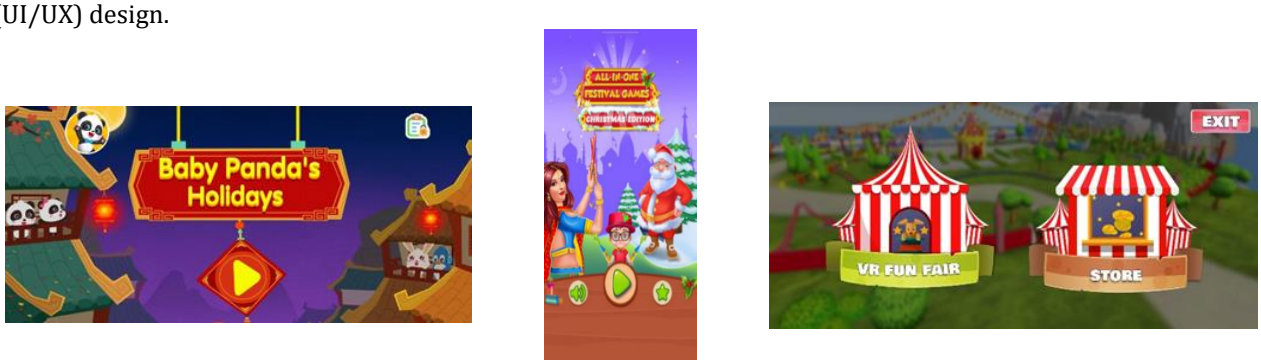
Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 771-790

virtual computer-generated environment through sights, audio, and haptics, which are often represented by headsets and gloves [9].

As the years go by, multiple researchers attempt to identify distinct application scenarios and advantages of virtual reality in many fields of study. Virtual reality can be used to efficiently address pain, anxiety, and other mental health difficulties. For example, there is research in [10] where they employed biofeedback adaptive VR to reduce anxiety and pain in surgery patients. Furthermore, VR also functions as a tool for fight simulations and training [11] that allows pilots to prepare for real-life conditions such as severe weather and malfunctioning engines in immersive cockpits.

2.3 Comparative Analysis

In this section, a comparison has been made between existing applications, such as Baby Panda's Chinese Festival [12], Festival Game - Casual Games [13], and Opposites Are Fun Fair [14], provide valuable insights for the development of proposed application. Figure 1 shows the main menu interface of the three existing applications. Meanwhile, seven features have been discussed, as shown in Table 1. It includes the technology used, operating system, content, learning module, activity modules, payment charges and user interface and user experience (UI/UX) design.



(a) **(b)** **(c)**

Fig. 1 *(a) Baby Panda's Chinese Festival*[12]*; (b) Festival Game - Casual Games*[13]*; (c) Opposites Are Fun Fair*[14]

Table 1 *Comparison between existing applications and proposed applications*

Features	Baby Panda's Chinese Holiday	Festival Game – Casual Games	Opposites Are Fun Fair VR	VR Malaysia FestiWorlds
Technology used	Mobile-based. Do not provide VR.	Mobile-based. Do not provide VR	Mobile-based. Provide non-immersive VR	Provide fully immersive VR features.
Operating system	Android 4.4 or higher	Android 4.4 or higher	Android 4.4 or higher	Windows-based
Content	Basic introduction to Chinese festivals.	Basic decoration and puzzle game for Christmas and Navratri festival.	No festival content. Opposite Vocabulary content in amusement park environment.	Three main races festivals and traditional food preparation in amusement park environment.
Learning module	Do not provide Learning module	Do not provide Learning module	Provide Learning module like recognize a pair of opposite vocabulary.	Provides a learning module like information of festival and origin of traditional foods.
Activity module	Provide activity module like food preparation, festival decoration and crafting.	Provide decoration activity and puzzle game.	Provide an activity module like amusement riding activities.	Provide a traditional food preparation and amusement riding as activities.
Payment charges	Free download.	Free download.	Free download, In-app purchases.	Free of charge.

Table 1 *Comparison between existing applications and proposed applications (cont.)*

Features	Baby Panda's Chinese Holiday	Festival Game – Casual Games	Opposites Are Fun Fair VR	VR Malaysia FestiWorlds
UI/UX design	Child-friendly and the interface is colorful and cartoonish.	Not user-friendly. The arrangement of activities in each festival is not consistent. For the UX, it provides feedback mechanisms.	User-friendly, the navigation is simple to understand, and the design is consistent.	It will provide a clear menu system and consistent visual design. The related background music will be implemented.

Based on Table 1, several strengths and limitations of the proposed application can be concluded. Firstly, the proposed application will provide fully immersive virtual reality features. Secondly, the application provides an easy-to-navigate and cost-free platform for users with its user-friendly design and free accessibility. The learning module will provide festival knowledge by indicating the origins of traditional foods, resulting in a deeper cultural understanding. The app's multiple features, which include traditional food preparation and amusement riding, offer an interesting experience for users with a wide range of interests. Importantly, VR Malaysia FestiWorlds aims to being freely accessible to a wider audience.

3. Methodology

VR Malaysia FestiWorlds is a 3D virtual reality application focus on Malaysia festival content. Thus, the TRES-D (ThREe dimensional uSer interface Development) methodology [15] is chosen to develop this application as shown in Figure 2. The output for the six phases of the TRES-D methodology is summarized in Table 2.

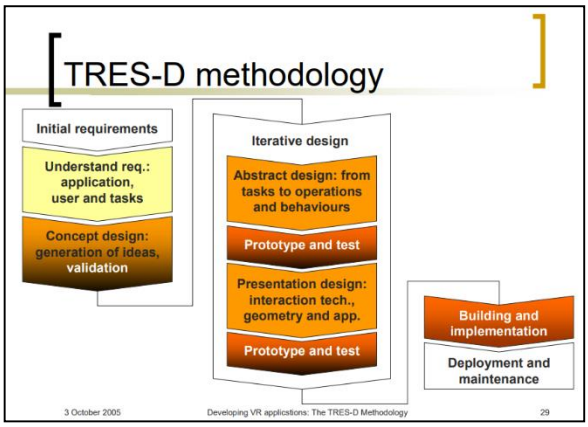


Fig. 2 *TRES-D methodology structure* [16]

Table 2 *System development workflow for proposed application*

Phase	Activities	Outputs
Initial Requirements	• Identify the project idea. • Identify the user analysis requirements. • Set initial application requirements. • Prepare time planning for requirements study.	• The project title, problem statement, objectives, project scope, project significance, and expected result. • Initial application requirement Checklist
Understand Requirements	• Analysis and understands project goals. • Analyse tasks and create key scenarios. • Identify the functional and nonfunction requirements. • Identify the hardware and software requirements. • Determine the object analysis and navigation analysis	• Documented project goals. • List of key scenarios. • Functional and non-functional requirements. • Hardware and software requirements. • Content structure checklist. • System flowchart. • Navigation structure

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 771-790

Table 2 *System development workflow for proposed application (cont.)*

Phase	Activities	Outputs
Concept Design	• Brainstorming to capture ideas.	• High-fidelity storyboard.
Iterative Design	• Design the application abstractly and presentational through iterative cycles.	• List of decomposition of Tasks and High-Level Dialogue • List of task details in presentation design iterations.
Building and Implementation	• Develop specifications and prototypes. • Create and animate the virtual world. • Program the interface and logic.	• Specifications and prototypes. • Animated virtual world. • Programmed interface and logic.
Deploy and Maintenance	• Finalize development. • Conduct functional testing on the developer. • Conduct the user acceptance test with the target user.	• Identify and solve the problems of the developed application. • User acceptance level on the usability, functionality, and performance of the application. • Completed VR application.

TRES-D methodology involves six primary stages that outline the core development tasks. The six primary stages in this methodology are initial requirements, understand requirements, concept design, iterative design, building and implementation, and deploy and maintenance.

3.1 Initial Requirements

In this stage, an application initial requirement checklist has been created as shown in Table 3. Simultaneously, a time planning strategy like Gantt Chart will be provided in Appendix A to efficiently manage the development of VR application process.

Table 3 *Initial Requirement Checklist*

Item	VR Malaysia FestiWorlds
Type of application	3D Virtual Reality Application
Target device	PC-based VR platform
Target users	Users aged 7 and above
Graphic User Interface (GUI)	Engaging visual design, intuitive navigation
Images	High-quality festival-related visuals
3D model	Detailed 3D models representing festival decorations, traditional food, and amusement rides, enhancing the visual richness of the VR environment
Animation	Dynamic animations depicting cultural festivities
Audio	Festival-specific music, ambient sounds
Application synopsis	VR Malaysia FestiWorlds is a 3D Virtual Reality Application developed to provide an immersive cultural experience centered around Malaysia's festivals. The application covers major ethnic festivals, offering an immersive food preparation activity, and festival decorations in an amusement park environment. The application aims to educate and entertain users about the cultural significance of festivals through a visually stunning and interactive VR environment.

In this stage, the initial requirements of the application like objective, problem statement, expected outcome, and project significance were discussed and set out. The information required before the design and development of the VR Malaysia FestiWorlds is determined.

3.2 Understand Requirements

In this phase, an analysis is done by gathering all information needed for a captivating virtual reality experience centered on Malaysian festivals. The proposed application was briefly explained, and the problem statement was defined, and the issue is clear. The objectives also have been determined to achieve the goal and the key scenario list was shown in Table 4, reflecting the essence of Malaysian festivals. The results of the user analysis are tabulated in Table 5.

Table 4 *Key Scenario List*

Subject Matter Expert Aspect	Key Scenario
Cultural Diversity	- Explore festivals of three main races in Malaysia.
	- Virtual engagement with traditional food preparation.
Immersive Learning	- Learn about the origin and significance of each festival.
	- Discover historical and cultural context in VR.
User Interaction	- Interact with virtual objects like festival decorations.
Education Enhancement	- Information about festival and traditional foods history and origin.
Multisensory Experience	- Immerse in background music enhancing festival ambiance.

Table 4 presents a list of key scenarios, indicating that the task analysis will involve collaboration with subject-matter experts. An interview session was conducted with a Subject Matter Expertise (SME), Teacher Gent Tan Qi Yi, who has 7 years of teaching experience in Darjah 6 Sejarah subjects at Qi Meng Education Centre in Johor. The transcript is attached in Appendix B.

Table 5 *User requirements Analysis*

User preferences	Descriptions
Interested aspects	• Exploring cuisine and food tradition VR application • Exploring festival decoration in VR application
Features	• Interactive Theme Park amusement ride with festival decoration • Information about the festival
Multimedia Elements	• 3D animation • Graphics or image
Types of Navigation	• Teleportation navigation • Menu-based navigation

Besides, a set of questionnaires is prepared and distributed to the target users via the Google Form. A total of 35 responses from target users has been collected as attached in Appendix C. For the user analysis, the highlighted issues are user experience analysis and user requirements analysis.

3.3 Concept Design

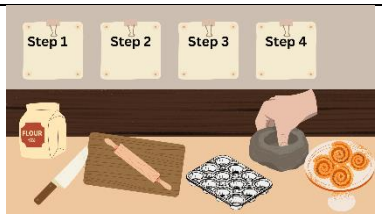
The major goal of this stage is to identify the tasks that the user will be able to execute with the application, as well as the hardware and software that will make it possible. A storyboard has been created to provide a visualization of the VR Malaysia FestiWorlds application as shown in Table 6.

Table 6 *Storyboard*

Interfaces	Description	Interfaces	Description
	3D virtual environment interface that will be display when the users enter the VR application.		This is the main menu interface. It consists of three buttons which are start, setting and credit button.
	When the users select the setting button, the users will navigate to the setting interface to control music and sound effect.		The users can engage with the virtual object in VR application by clicking the virtual object

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 771-790

Table 6 *Storyboard (cont.)*

Interfaces	Description	Interfaces	Description
	The information interface will show, and the user can click start to experience amusement ride activities.		3D virtual environment interface that displays three festival tents.
	This interface displays the information of traditional food according to the tents that selected by the users.		This is the traditional food preparation interface that in the tent.

The primary goal of this stage is to identify the functional requirements, as well as the non-functional requirements that will enable them to perform so. The functional requirements and non-functional requirements were tabulated in Table 7 and Table 8 respectively.

Table 7 *Functional requirements*

Functional requirements	Module	Description
Autonomous system activities	Immersive Activity Module	• The information details of decoration elements should display when the users pointed decoration element.
	Traditional Food Preparation Module	• The graphic of the step to prepare food should be shown when the users start the traditional food preparation module. • The application shall go to the next step after the user has successfully completed the current step.
	Audio	• Background music should play when the users enter all the modules.
Provide learning content	Immersive Activity Module	• The application should allow users to click on interactive elements within the amusement rides to learn festivals' information.
	Traditional Food Preparation Module	• The application should allow users to click on interactive elements within the food preparation menu to learn history of traditional food information.
User interaction support	Main Interface	• The application should allow users to click on the start button to start the application.
	Main Menu	• The application should allow users to select an activity by clicking on the labelled buttons.
	Immersive Activity Module	• The application should allow users to virtually ride amusement rides after the users click start to provide an immersive and entertaining experience.
	Traditional Food Preparation Module	• The application should allow users to engage with virtual objects, such as ingredients and cooking utensils to provide a hands-on experience in a virtual kitchen setting.
	Learning Module	• The application should allow users to click on interactive elements within the amusement rides to learn festivals' information. • The application should allow users to click on interactive elements within the food preparation menu to learn history of traditional food information.
	Main Interface	• The application should allow users to click on the start button to start the application.
	Main Menu	• The application should allow users to select an activity by clicking on the labelled buttons.

Table 7 *Functional requirements (cont.)*

Functional requirements	Module	Description
User interaction support	Immersive Activity Module	• The application should allow users to virtually ride amusement rides after the users click start to provide an immersive and entertaining experience.
	Traditional Food Preparation Module	• The application should allow users to engage with virtual objects, such as ingredients and cooking utensils to provide a hands-on experience in a virtual kitchen setting.
	Learning Module	• The application should allow users to click on interactive elements within the amusement rides to learn festivals' information. • The application should allow users to click on interactive elements within the food preparation menu to learn history of traditional food information.

Table 7 outlines the VR application's functional requirements, including modules for autonomous system activities, learning content, and user interaction support, with background music and easy navigation for a seamless experience.

Table 8 *Non-functional requirements*

Non-functional requirements	Description
Performance	• The application should be able to load all the modules. • The average response time between click and reaction shall be 3 seconds. • The VR application should maintain a minimum frame rate of 60 frames per second (FPS) to ensure smooth and comfortable user navigation within the virtual environment.
Legal	• Users should be only able to view the content but cannot modify the content.
Usability	• The application shall be user-friendly and easy to use for the users. • The user interface should be intuitive, with clear navigation cues and labels to enhance user understanding.
Operational	• The application shall be able to operate with Windows platform.
Cultural	• The application shall be developed in English language.

Table 8 shows non-functional requirements include performance, legal constraints, usability, compatibility, and cultural considerations, aiming for smooth performance, content integrity, user-friendly interface, Windows operation, and English development. The hardware and software requirements for both developer and users were show in Table 9 and Table 10.

Table 9 *Hardware requirements for the user*

Requirements	Item	Description
Hardware	Computer	Allow users to install and launch the application. Minimum specifications requirements are as follows: • Operating System: Windows 10(minimum) • Processer: Multi-Core Processor • Graphics: NVIDIA GeForce RTX Series (Recommended) • Installed Memory (RAM): 8.00GB • Storage: Sufficient storage space for download application
	VR Headset	Allow users to explore the VR environment. • RAM: 4GB and above • Storage: 64GB and above • Video output: DisplayPort 1.2 or newer • Operating system: Windows 10 or above • USB port: 1x USB 3.0 or newer

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 771-790

Table 10 *Hardware and software requirements for the developer*

Requirements	Item	Description
Hardware	Laptop (ACER NITRO 5 AN515-57)	Allow the developer to use software to develop and test the application. • Operating System: Windows 11 • Processer: 11th Gen Intel® CoreTM i5-11400H@2.70GHz 2.69 GHz • Graphics: NVIDIA GeForce RTX3060 • Installed Memory (RAM): 8.00GB • Storage: 512GB HDD
	VR Headset	Allow users to test the VR environment. • RAM: 4GB and above • Storage: 64GB and above • Video output: DisplayPort 1.2 or newer • Operating system: Windows 10 or above • USB port: 1x USB 3.0 or newer
	Input-output devices	Allow the developers to communicate with the computer. Devices are including mouse, keyboard and headphone.
Software	Canva	To design the storyboard.
	Blender	To create the 3D animation.
	Unity 3D	To integrate the asset of the application.
	Visual Studio 2019	To write the C# script for the application.

Table 9 and Table 10 outline the essential hardware and software requirements for both users and developers to ensure the effective functioning and development of the VR application. These requirements ensure that users have a smooth and immersive experience while developers have the necessary tools to create and test the application efficiently.

3.4 Iterative Design

The chosen solution undergoes an in-depth design process at two levels: abstract and presentation, throughout the iteration design phase developed for VR Malaysia FestiWorlds.

3.4.1 Abstract Design

The conceptual designs for the virtual world are created, defining the exact placement of virtual objects, and identifying immersive navigation paths. System flowcharts and navigation structures are used in abstract design. Figure will show the system flowchart which illustrates data, processes, and interactions within an application. While Figure shows the navigation structures that outline the user's journey through the application.

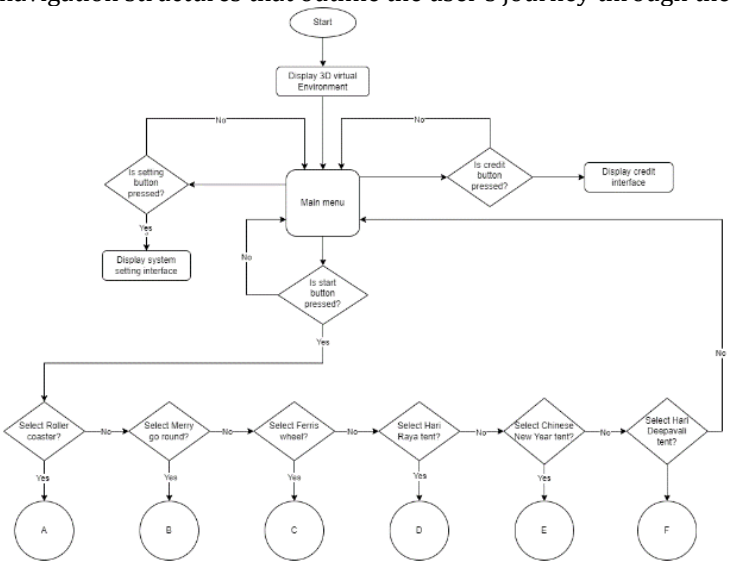


Fig. 3 *System Flowchart*

Figure 3 shows that the application will launches in a 3D virtual world, with a main menu for settings, credits, and experience start options. Users can select from various amusement rides or festival tents, such as roller coaster, merry-go-round, Ferris wheel, Hari Raya tents, Chinese New Year tents, and Hari Deepavali tents.

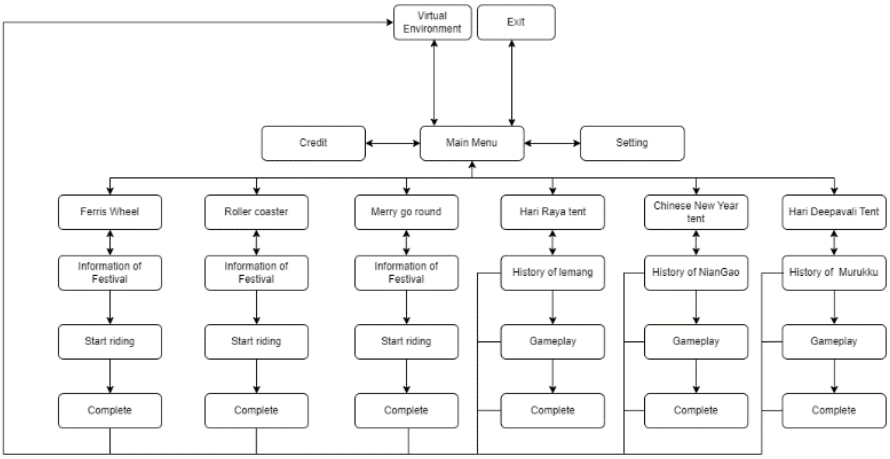


Fig. 4 *Navigation Structure*

Figure 4 shows Users can access the main menu, credits, settings, and various attractions or festival tents. Attractions like Ferris Wheel, Roller Coaster, and Merry Go Round provide festival information, while festival tents offer historical information and gameplay elements. Users can return to the main menu or exit the application.

3.4.2 Presentation Design

The concept design process involves detailed low-level dialogue, interaction styles, and basic tasks, while collecting reference material from real world models and integrating the virtual world into the application interface. Table 11 shows the tasks will be done in this level. The button design also will be done in this phase and show in Table 12.

Table 11 *Task details in Presentation Design*

Tasks	Details
Selecting Interaction Styles	Using input devices to interact with virtual objects, mimicking participation in traditional Malaysian festival activities.
Basic Interaction Tasks	Users can interact with objects by using device controllers to perform specific tasks.
Concrete Interaction Techniques	Device controllers is used in the application to enable users to interact with objects in the virtual world.
Design of World Structure	A virtual amusement ride that with traditional festival's decorations can be designed to showcase the celebration of "Hari Raya,".
Geometry and Appearance	Cultural elements, like "ketupat" (a traditional Malaysian food), require detailed design of their geometry to render them in the application.
Reference from Real-World Models	Reference material can be gathered from real-world models, ensuring that the virtual version is as authentic as the actual food, such as "lemang".

Table 12 *Button Design*

Button	Description
	• This is a start button. • It will bring users into the 3D virtual environment.
	• This is a setting button. • It opens the setting interface.
	• This is a credit button. • It opens the credit interface.
	• This is a apply button. • It saves the users' changes in setting interface.
	• This is a close button. • It closes the pop-up windows.

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 771-790

3.5 Building and Implementation

The main functions of the proposed application are developed in this phase. The main modules encompass two key components: the food preparation activity module and the immersive activity module. The C# scripting will be used to allows users engage with virtual objects, explore festival decorations, and participate in traditional food preparation. The audio controls also provided in the setting menu enables users to control the background music and sound. Finally, prototypes of the modules are integrated with the C# script to link each amusement rides, tent, and users' navigation path.

Table 13 *Application Asset Development*

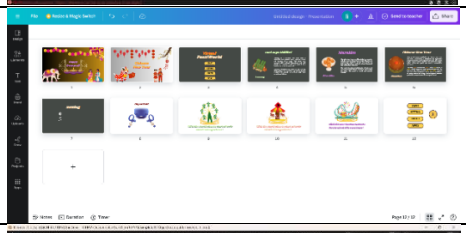
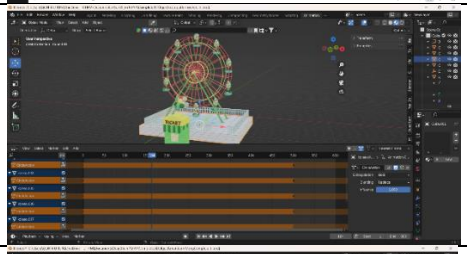
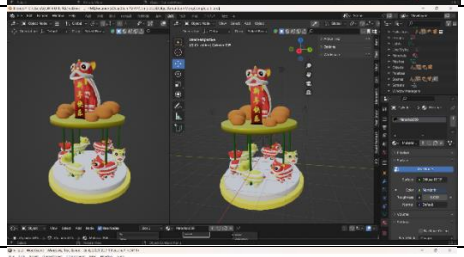
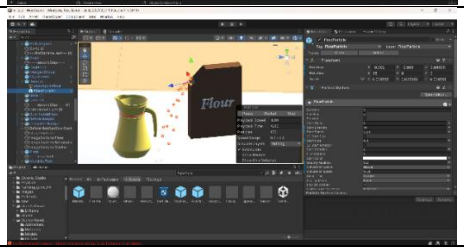
Assets	Development	Description
Audio		The audio files are saved in Moving Picture Experts Group Layer-3 Audio (MP3) format and all audio is downloaded from the free online website.
Graphics		Canva platform was used to design the storyboard and interface of the application. The designs were then downloaded from the Canva platform, and the background of the elements was set to transparent.
3D animation		In the application, there are 3 animations created from Blender software which are the amusement rides in the application. By inserting the keyframe, the amusement ride will be animated.
3D model		Blender software was used to create all the 3D models that have in the application. All the amusement rides models are model from Blender software such as ketupat Ferris wheel, Lion Dance Carousel and Diya Roller Coaster.
Particle System		Many types of particle system have been created in Unity 3D for food preparation activity to simulate the fluid and powder's behaviuor.

Table 13 outlines the development of various assets for the VR application, ensuring a rich and immersive user experience. These assets enhance the application's visual and interactive quality, providing users with an engaging and realistic VR experience.

Table 14 *Integration in Unity*

Function	C# Script	Description

Switch between main camera and amusement rides camera	public class CCameraSwitcher : MonoBehaviour
	{
	public Camera mainCamera;
	public Camera CarouselCamera;
	private void Start() {
		This script is used to switch between two cameras in the application. The SwitchToMainCamera

Table 14 *Integration in Unity (cont.)*

Assets	Development	Description

(CcameraSwitcher)	mainCamera.enabled = true;
	CarouselCamera.enabled = false; }
	public void SwitchToMainCamera() {
	mainCamera.enabled = true;
	CarouselCamera.enabled = false; }
	public void SwitchToCarouselCamera() {
	mainCamera.enabled = false;
	CarouselCamera.enabled = true; }
	}
		method switches back the view to the main camera However, the SwitchToCarouselCamera method switches the view to the carousel camera.

Enable flour particle trigger with bowl and accumulate (Flour Accumulator)	void OnParticleTrigger() {
	HandleFlourParticles();
	HandleWaterParticles();
	}
	void HandleFlourParticles() {
	List<ParticleSystem.Particle> enterParticles = new List<ParticleSystem.Particle>();
	int numEnter = flourParticleSystem.GetTriggerParticles(ParticleSystemTriggerEventType.Enter, enterParticles);
	if (numEnter > 0) {
	if (flourMeshRenderer != null && !flourMeshRenderer.enabled) {
	flourMeshRenderer.enabled = true;
	}
	currentFlourAmount += incrementAmount * numEnter;
	UpdateFlourMesh();
	}
	for (int i = 0; i < enterParticles.Count; i++) {
	var particle = enterParticles[i];
	particle.remainingLifetime = 0;
	enterParticles[i] = particle;
	}
	flourParticleSystem.SetTriggerParticles(ParticleSystemTriggerEventType.Enter, enterParticles);
	}
		This script is used for all particle systems that can be poured in the scene, such as flour particles, to trigger action between the particle system and the bowl. The OnParticleTrigger method is triggered when particles interact with a specific area, and it calls two methods, which are HandleFlourParticles and HandleWaterParticles. HandleFlourParticles checks for particles entering the flour particle system's trigger area, increments the flour amount, and updates the mesh scale and visibility accordingly.

Show tooltip when user hovering over an object (TooltipHandler)	public void ShowTooltip(HoverEnterEventArgs args)
	{
	if (activeTooltipHandler != null && activeTooltipHandler != this) {
	activeTooltipHandler.HideTooltip();
	}
	if (currentTooltip != null && mainCamera != null) {
	activeTooltipHandler = this;
	Vector3 cameraPosition = mainCamera.transform.position;
	Vector3 cameraForward = mainCamera.transform.forward;
	Vector3 tooltipPosition = cameraPosition + cameraForward * distanceFromCamera;
	if (tooltipPosition.y < floorHeight) {
	tooltipPosition.y = floorHeight + 0.5f; }
	currentTooltip.transform.position = tooltipPosition;
	Vector3 directionToCamera = (cameraPosition - tooltipPosition).normalized;
	Quaternion lookRotation = Quaternion.LookRotation(directionToCamera);
	currentTooltip.transform.rotation = lookRotation;
		The TooltipHandler script enables a tooltip to pop up and show information when a user hovers over a decoration object in a VR environment. When the object is hovered over, the 'ShowTooltip' method calculates the position and orientation of the tooltip so that it activates the tooltip, and the tooltip will appear at a fixed distance in front of the main camera and above the floor. The 'HideTooltip' method hides the tooltip when the hover ends.

Table 14 *Integration in Unity (cont.)*

Assets	Development	Description

	currentTooltip.transform.Rotate(0, 180, 0);
	currentTooltip.SetActive(true); }
	}
	public void HideTooltip(HoverExitEventArgs args) {
	if (currentTooltip != null && activeTooltipHandler == this) {
	currentTooltip.SetActive(false);
	activeTooltipHandler = null; }}
	}	

Control pouring behavior to simulate pouring effect (Pour)	void Update() {
	float xRotation = transform.rotation.eulerAngles.x;
	enough to pour (between -26 degrees and 21 degrees)
	if ((xRotation >= minPourAngle && xRotation <= maxPourAngle) || (xRotation >= minPourAngle && xRotation <= maxPourAngle)) {
	float rate = CalculatePouringRate();
	var emission = ps.emission;
	emission.rateOverTime = rate;
	}
	else {
	var emission = ps.emission;
	emission.rateOverTime = 0;
	}
	}
	float CalculatePouringRate() {
	return maxRate;
	}
	float Remap(float source, float sourceFrom, float sourceTo, float targetFrom, float targetTo) {
	return targetFrom + (source - sourceFrom) * (targetTo - targetFrom) / (sourceTo - sourceFrom);
	}
	}
		This script controls the pouring behavior of an object in Unity by using a particle system to simulate the pouring effect. In the Update method, it continuously checks the object's X-axis rotation to determine if the object is within the specified pour angle range (minPourAngle to maxPourAngle). If the object is within this range, it calculates the pouring rate using the CalculatePouringRate method and adjusts the emission rate of the particle system accordingly. If the object is not within the pouring angle range, it stops the pouring effect.

Furthermore, the C# scripts are developed to enable the main functions of the application. For examples, functions implement animations, switch camera, pour particle system and handle tooltip prefab. These functions are explained in Table 14.

3.6 Deploy and Maintenance

In the last phase, two types of testing will be performed, including functional testing and user acceptance testing. If errors are discovered in this phase, the project will return to the previous phase to update the integrated functions to fix the errors.

Table 15 *Functionality Testing*

Test	Expected Result	Actual Result	Corrective Action
Start button	Start exploring the virtual reality world.	Works well as expected.	Not needed.
Setting Button	Navigate to the setting panel.		
Credit Button	Navigate to credit panel.		
Apply Button	Apply the setting in setting panel.		
Next Button	Navigate to next information page for festival information section.		
XR grab interaction.	Grab all the object in the scene without glitches.		

Table 15 *Functionality Testing (cont.)*

Test	Expected Result	Actual Result	Corrective Action
XR release interaction	Objects are released and fall naturally due to gravity.	Works well as expected.	Not needed.
Switch between main camera and amusement ride camera.	Camera switches smoothly and shows the correct view.		
Switch images in the cooking section interface.	Images switch correctly with next and previous button press.		
Audio	Play audio.		
Ensure the box collider prevents the user from passing through objects.	The user cannot move through the object, and collision is detected.		
Activate a particle system when an object is poured.	The particle system activates and simulates the pouring effect.		
Teleport to another location	The user is smoothly teleported to the selected location.		
Animation	Play animation.	The animation cannot play completely when imported from blender.	Combine all non-linear animation in Blender before exported to Unity.
Trigger particle system to accumulate.	Mesh filter shows the accumulation correctly.	The particle system cannot be trigger with the bowl.	Add box collider to the bowl and attach it into the collides properties in particle system inspector.
XR hover interaction	Tooltips or visual feedback appear when hovering over objects.	The tooltip was overlay with another object when it appears.	Set the distance from camera and floor height value in the script.
Attach object to a socket	The object snaps to the socket position and orientation.	The object cannot snap to the socket in proper position and rotation.	Assign attach position in the XR socket interaction component.

The functional testing is presented in Table 12 and these corrective measures ensure smooth performance and an enhanced user experience in the VR environment. while the user acceptance testing will be discussed in Section 4.

4. Result and Discuss

User acceptance testing is performed to ensure that the application works as designed. Each module's performance was examined. System Usability Scale (SUS) was adopted and applied to assess user acceptance of the developed application [17]. The System Usability Scale (SUS) is a ten-item Likert scale designed to provide a global view of subjective usability evaluation. A total number of 35 respondents are involved in the user acceptance testing.

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 771-790

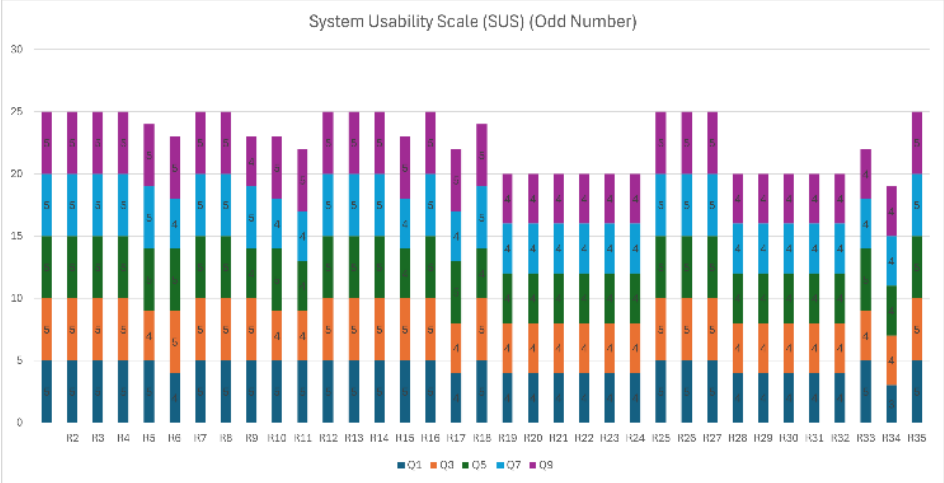


Fig. 5 *System Usability Scale Output(Odd Number)*

Question 1: I think that I would like to use this VR application frequently.
Question 3: I thought the application was easy to use.
Question 5: I found the various functions in this VR application were well integrated.
Question 7: I would imagine that most people would learn to use this VR application very quickly.
Question 9: I felt very confident using the VR application.

Fig. 6 *System Usability Scale (Odd Number)*

Based on Figure 5, most of the respondents selected 4 (Agree) and 5 (Strongly Agree) for positive statements, demonstrating an agreement that the application is satisfactory and easy to use. Overall, the results show a high degree of user satisfaction and efficient use of the application.

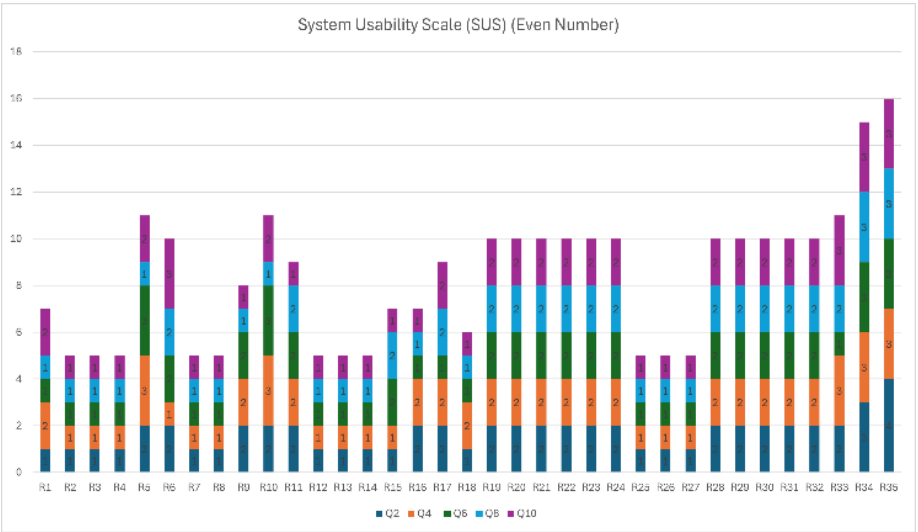


Fig. 7 *System Usability Scale Output (Even Number)*

Question 2: I found the application unnecessarily complex.
Question 4: I think that I would need assistance to use the VR application.
Question 6: I thought there was too much inconsistency in this application.
Question 8: I found the application very cumbersome to play.
Question 10: I needed to learn a lot of things before I could get going with this application.

Fig. 8 *System Usability Scale (Even Number)*

In the Figure 7, the results for negative statements in the questionnaire show that almost all respondents gave scores between 1 (Strongly Disagree) and 3 (Neutral). This indicates that users do not perceive significant problems with the application. These low scores on negative statements match the high scores on positive statements, showing that users find the system easy to use and satisfactory.

Table 16 *Respondent's Score*

Respondent	Item Score										TOTAL SCORE
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**	
R1	5	1	5	2	5	1	5	1	5	2	95
R2	5	1	5	1	5	1	5	1	5	1	100
R3	5	1	5	1	5	1	5	1	5	1	100
R4	5	1	5	1	5	1	5	1	5	1	100
R5	5	2	4	3	5	3	5	1	5	2	82.5
R6	4	2	5	1	5	2	4	2	5	3	82.5
R7	5	1	5	1	5	1	5	1	5	1	100
R8	5	1	5	1	5	1	5	1	5	1	100
R9	5	2	5	2	4	2	5	1	4	1	87.5
R10	5	2	4	3	5	3	4	1	5	2	80
R11	5	2	4	2	4	2	4	2	5	1	82.5
R12	5	1	5	1	5	1	5	1	5	1	100
R13	5	1	5	1	5	1	5	1	5	1	100
R14	5	1	5	1	5	1	5	1	5	1	100
R15	5	1	5	1	4	2	4	2	5	1	90
R16	5	2	5	2	5	1	5	1	5	1	95
R17	4	2	4	2	5	1	4	2	5	2	82.5
R18	5	1	5	2	4	1	5	1	5	1	95
R19	4	2	4	2	4	2	4	2	4	2	75
R20	4	2	4	2	4	2	4	2	4	2	75
R21	4	2	4	2	4	2	4	2	4	2	75
R22	4	2	4	2	4	2	4	2	4	2	75
R23	4	2	4	2	4	2	4	2	4	2	75
R24	4	2	4	2	4	2	4	2	4	2	75
R25	5	1	5	1	5	1	5	1	5	1	100
R26	5	1	5	1	5	1	5	1	5	1	100
R27	5	1	5	1	5	1	5	1	5	1	100
R28	4	2	4	2	4	2	4	2	4	2	75
R29	4	2	4	2	4	2	4	2	4	2	75
R30	4	2	4	2	4	2	4	2	4	2	75
R31	4	2	4	2	4	2	4	2	4	2	75
R32	4	2	4	2	4	2	4	2	4	2	75
R33	5	2	4	3	5	1	4	2	4	3	77.5
R34	3	3	4	3	4	3	4	3	4	3	60
R35	5	4	5	3	5	3	5	3	5	3	72.5
Average Score											**85.93**

Table 16 shows the analysis of respondent's score from the questionnaire (Google Form). The formula used to obtain usability results based on the SUS are:

$$SUS\ score = 2.5 \times \left(\sum_{k=1,3,5,7,9} (Response_k - 1) + \sum_{j=2,4,6,8,10} (5 - Response_j) \right)$$

Odd items = $\sum_{k=1,3,5,7,9}(Response_k - 1)$

Even items=$\sum_{j=2,4,6,8,10}(5 - Response_j)$

Therefore,

$$\text{Average score} = \frac{\text{Total score of R1 + R2 + R3 +}\cdots\text{R35}}{35}$$

$$= 85.93$$

Fig. 9 *System Usability Scale (Formula)*

Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 771-790

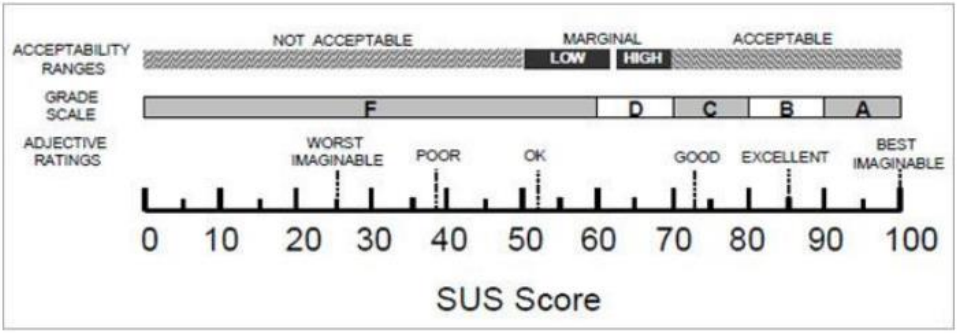


Fig. 10 *System Usability Scale (SUS)* [17]

The total scores for each question from the user testing was determined using a method based on the System Usability Scale (SUS), generating the total scores for each question. The Acceptability Ranges score scale places the average score of 86.25 into the "acceptable" range. "B" is the grade scale, and "Excellent" is the adjective rating. Overall, the built-in application effectively satisfies the needs of the target users.

5. Conclusion

Based on the results analysed from the testing phase, the VR Malaysia FestiWorlds application is suitable for the target users to increase understanding of Malaysian festival. The three objectives of this project were fully accomplished by first implementing 3D models to create the 3D virtual environment. Second, successfully developing VR Malaysia FestiWorlds application by using virtual reality technology. Lastly, performing the functional and user acceptance testing after the development phase was completed.

Table 17 *Advantages and Limitations of Application*

Advantages	Limitations
VR Malaysia FestiWorlds application had various well-integrated functions and interactive interaction.	Only include one traditional food preparation activities of each festival.
VR Malaysia FestiWorlds application had simplicity design.	Only include three Malaysian festivals in the application.
VR Malaysia FestiWorlds had a stable and predictable user experience with consistent functionality.	The users could not customize their traditional customs in the application.
VR Malaysia FestiWorlds had an intuitive and straightforward navigation.	It doesn't enable multiplayer functionality to allow users to attend festivals with friends in a shared virtual space.

Additionally, the advantages and limitations of the VR Malaysia FestiWorlds application are tabulated in Table 17. Finally, for future work, it is recommended to incorporate more Malaysian festivals into the application. In addition, each festival can also add more traditional food preparation activities.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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Appendix A: Gantt Chart

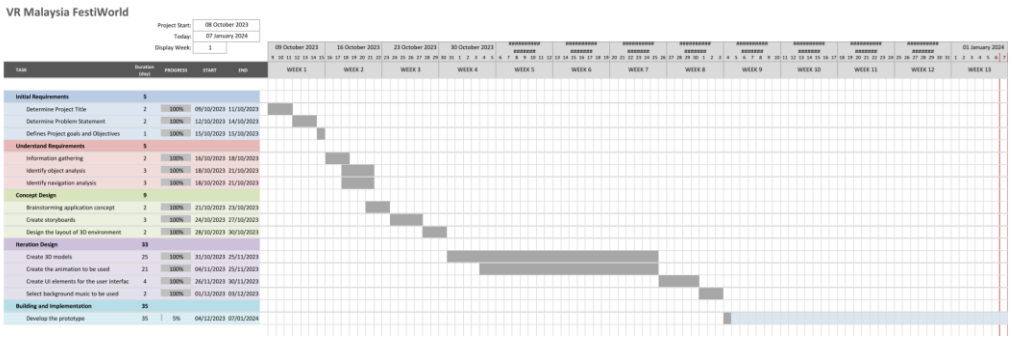


Fig. 11 *Gantt Chart for Final Year Project semester 1 2023/2024*

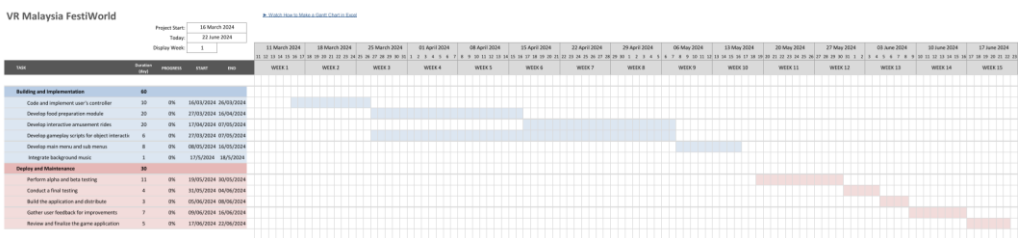


Fig. 12 *Gantt Chart for Final Year Project semester21 2023/2024*

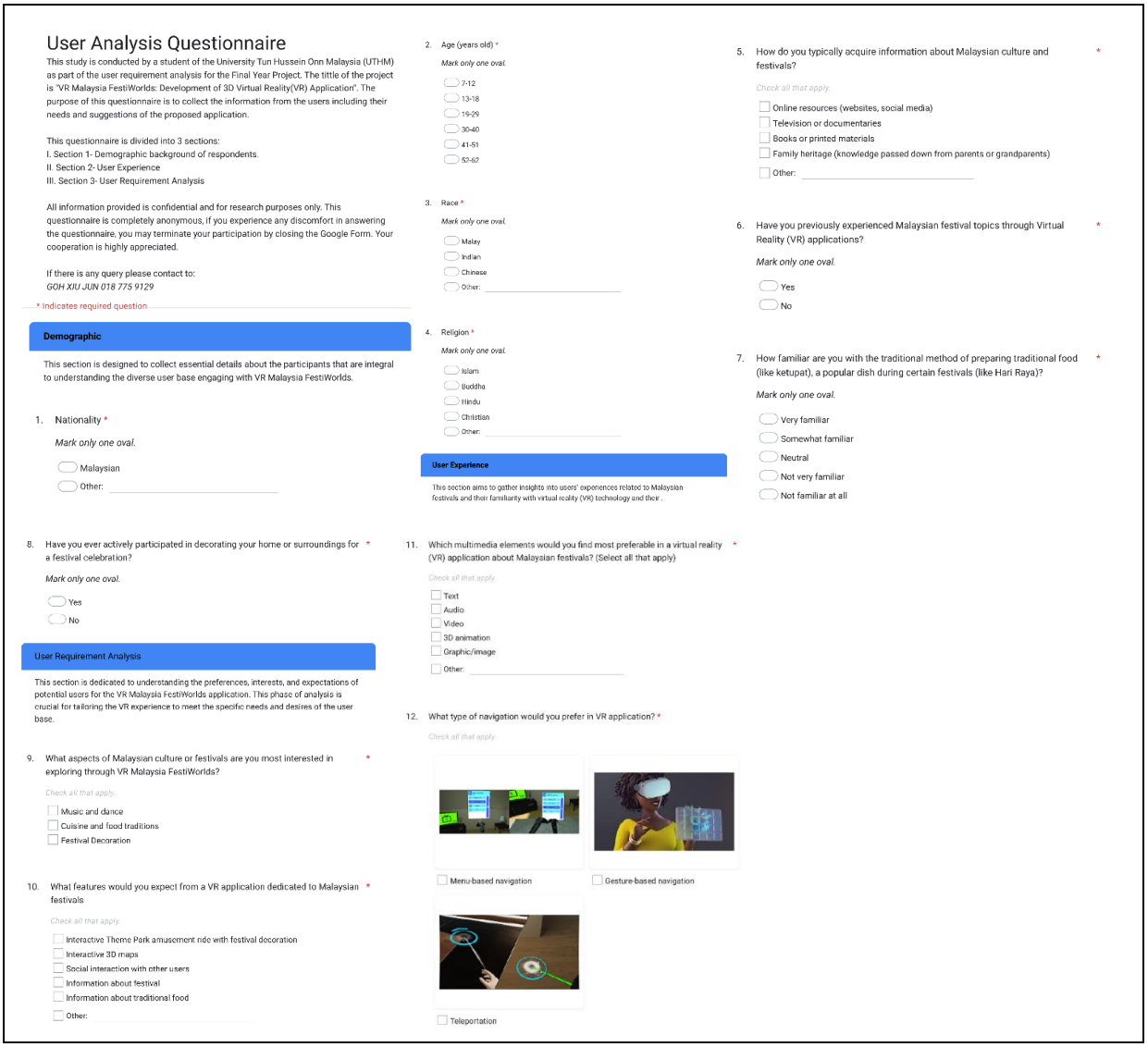
Applied Information Technology and Computer Science Vol. 5 No. 2 (2024) p. 771-790

Appendix B: Transcript of interview

Xiu Jun	:	Good evening! Sir, my name is Goh Xiu Jun, and I am a degree student at UTHM. Currently preparing for my final year project. In this project, I need to develop a virtual reality application for Malaysia festival. I am here to invite you to participate in this interview session to help me complete this project. Before we start, could you please introduce yourself?
Teacher Gent	:	Sure, you can call me Teacher Gent, I am currently working at Qi Meng Education in Pontian, Johor.
Xiu Jun	:	Yes, Teacher Gent, how many years' experiences in teaching Primary six history subject? Can you discuss about the history curriculum that related to the festival topic?
Teacher Gent	:	Yes, I have more than 5 years' experience in teaching history among primary six students. Ya, the primary six textbook really have topic related to the Malaysia festival.
Xiu Jun	:	Okay, I would like to know how you currently approach teaching about Malaysia Festivals to make it interesting and educational for primary six students?
Teacher Gent	:	I currently use the primary six textbook and some exercise books to teach this topic. Besides, I also will use some multimedia resources like YouTube video to make my class more interesting.
Xiu Jun	:	Do you find any limitations in capturing the attention and interest of the students with the current traditional teaching approaches for Malaysia Festivals?
Teacher Gent	:	Yes, maintaining students' interest can be a challenge. Traditional approaches might not always cater to the diverse learning styles and preferences of students, making it challenging to keep them engaged throughout the lessons.
Xiu Jun	:	I am designing a VR application; do you think this topic is suitable as a content for public?
Teacher Gent	:	I think this is a great idea. Virtual reality could offer immersive experiences, allowing public to virtually participate in festival activities, explore historical settings, and interact with cultural artifacts especially for students and those who never participate in Malaysia festival. This would deepen their understanding in an engaging way.
Xiu Jun	:	Is there any content that related to festival that I should have in the application? Do you think traditional food preparation technique is important?
Teacher Gent	:	The information can be the origin and history of traditional food. The technique also important to let the public pass on the traditional food preparation and you should make sure the content is correct. The application also can provide the details information of the festivals.
Xiu Jun	:	Do you think the interaction in the application is important or the application should only display the information to user?
Teacher Gent	:	It should allow the users to interact with the objects in the application, especially crafting activities like food preparation. The application also should provide suitable background music enhancing festival ambiance.
Xiu Jun	:	Okay. Now, please allow me to share my storyboard which is the design of the application with you.
Teacher Gent	:	Sure, go ahead.
Xiu Jun	:	Do you have any advice of my information that contain in my storyboard?
Teacher Gent	:	Yes. The information can be done in video format and avoid in more text form. You should make sure the users should read the information first before starting any activity in the application. This will let them learn and understand the details of the festival.
Xiu Jun	:	Noted. Teacher Gent, I will try to modify that. Do you have anything to add?
Teacher Gent	:	I think that is all for me.
Xiu Jun	:	Alright, teacher. Thank you so much for lending your time to me.

Fig. 13 *Transcript of interview*

Appendix C : User Analysis Questionnaire Form



User Analysis Questionnaire

This study is conducted by a student of the University Tun Hussein Onn Malaysia (UTHM) as part of the user requirement analysis for the Final Year Project. The tittle of the project is "VR Malaysia FestiWorlds: Development of 3D Virtual Reality(VR) Application". The purpose of this questionnaire is to collect the information from the users including their needs and suggestions of the proposed application.

This questionnaire is divided into 3 sections:
I. Section 1- Demographic background of respondents.
II. Section 2- User Experience
III. Section 3- User Requirement Analysis

All information provided is confidential and for research purposes only. This questionnaire is completely anonymous, if you experience any discomfort in answering the questionnaire, you may terminate your participation by closing the Google Form. Your cooperation is highly appreciated.

If there is any query please contact to:
GOH XIU JUN 018 775 9129

* Indicates required question

Demographic

This section is designed to collect essential details about the participants that are integral to understanding the diverse user base engaging with VR Malaysia FestiWorlds.

1. Nationality *
Mark only one oval.
Malaysian
Other:

2. Age (years old) *
Mark only one oval.
7-12
13-18
19-29
30-40
41-51
52-62

3. Race *
Mark only one oval.
Malay
Indian
Chinese
Other:

4. Religion *
Mark only one oval.
Islam
Buddha
Hindu
Christian
Other:

User Experience

This section aims to gather insights into users' experiences related to Malaysian festivals and their familiarity with virtual reality (VR) technology and their .

5. How do you typically acquire information about Malaysian culture and festivals? *
Check all that apply.
Online resources (websites, social media)
Television or documentaries
Books or printed materials
Family heritage (knowledge passed down from parents or grandparents)
Other:

6. Have you previously experienced Malaysian festival topics through Virtual Reality (VR) applications? *
Mark only one oval.
Yes
No

7. How familiar are you with the traditional method of preparing traditional food (like ketupat), a popular dish during certain festivals (like Hari Raya)? *
Mark only one oval.
Very familiar
Somewhat familiar
Neutral
Not very familiar
Not familiar at all

8. Have you ever actively participated in decorating your home or surroundings for a festival celebration? *
Mark only one oval.
Yes
No

User Requirement Analysis

This section is dedicated to understanding the preferences, interests, and expectations of potential users for the VR Malaysia FestiWorlds application. This phase of analysis is crucial for tailoring the VR experience to meet the specific needs and desires of the user base.

9. What aspects of Malaysian culture or festivals are you most interested in exploring through VR Malaysia FestiWorlds? *
Check all that apply.
Music and dance
Cuisine and food traditions
Festival Decoration

10. What features would you expect from a VR application dedicated to Malaysian festivals *
Check all that apply.
Interactive Theme Park amusement ride with festival decoration
Interactive 3D maps
Social interaction with other users
Information about festival
Information about traditional food
Other:

11. Which multimedia elements would you find most preferable in a virtual reality (VR) application about Malaysian festivals? (Select all that apply) *
Check all that apply.
Text
Audio
Video
3D animation
Graphic/image
Other:

12. What type of navigation would you prefer in VR application? *
Check all that apply.
Menu-based navigation
Gesture-based navigation
Teleportation

Fig. 14 *Goggle Form of User Analysis*

Appendix D: Evidence of User Acceptance Testing

Fig. 15 *Evidence of User Acceptance Testing*